a-SiGe - Stabilized Performance and Deposition Rate

1. Silane instead of disilane at high rate
2. Higher temperature - less germanium
3. Grading optimized for higher rate deposited material

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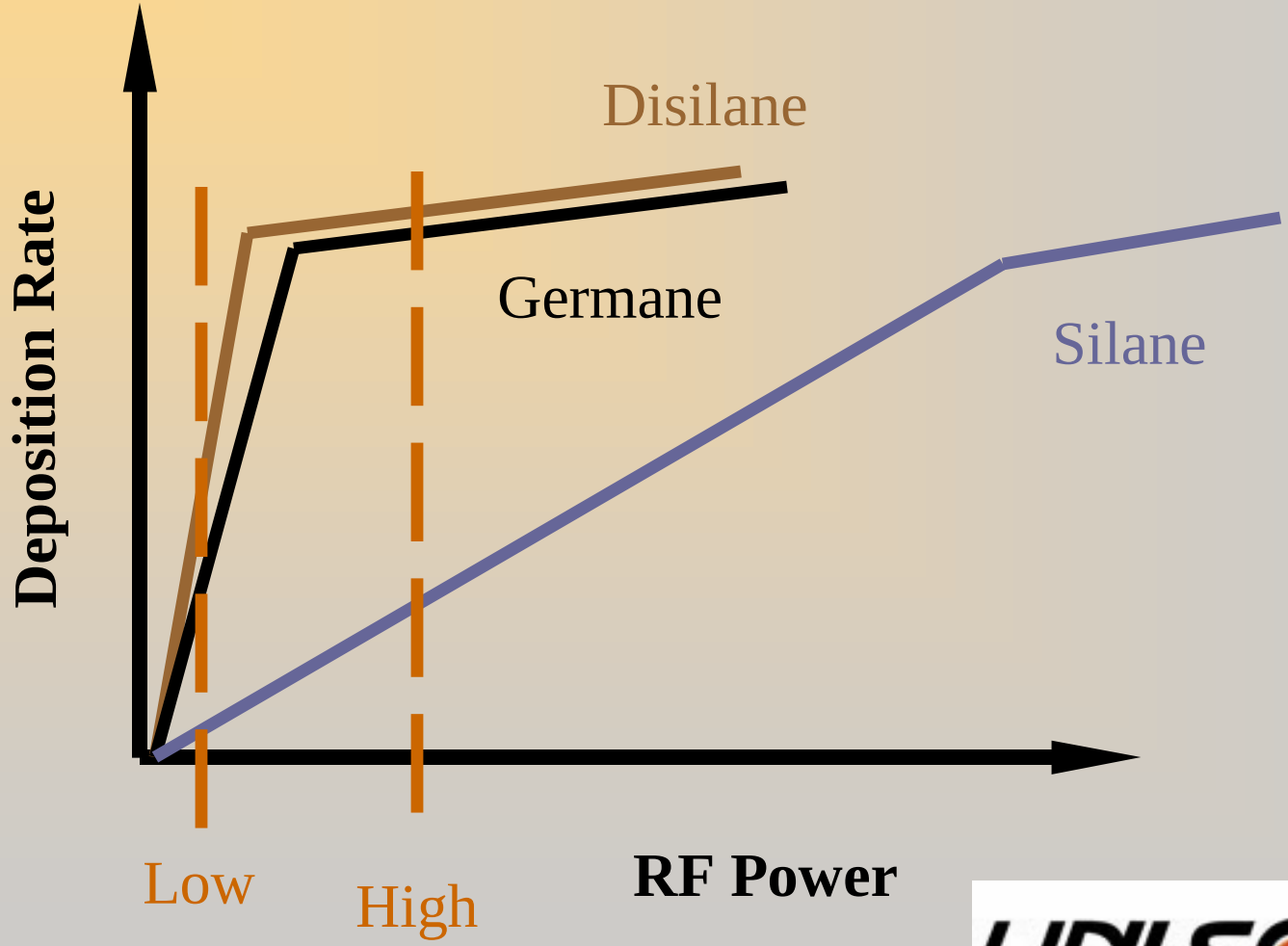
From Disilane to Silane



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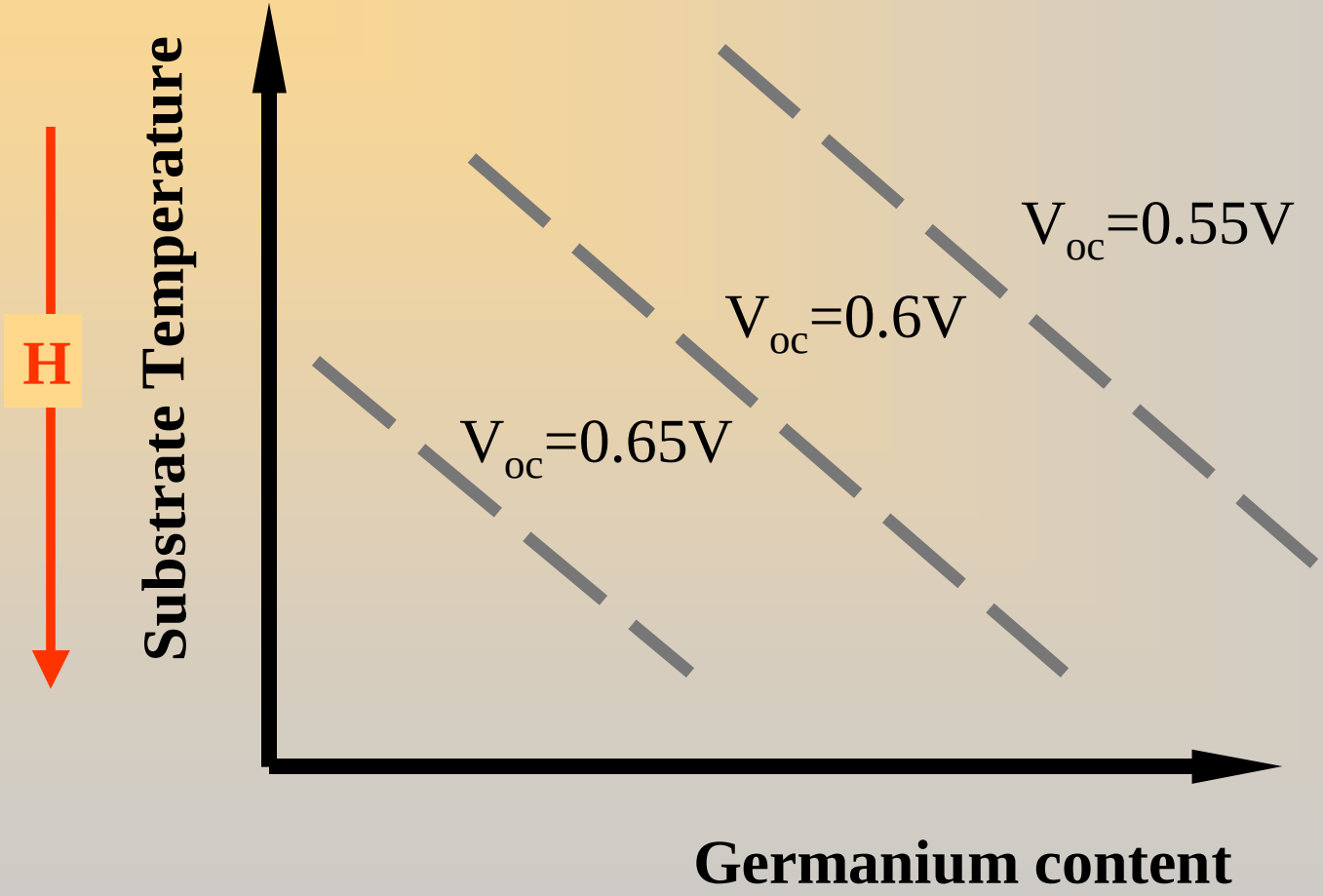
V_{oc} vs. Ge, H content



Adapted from
Terakura, PhD Thesis

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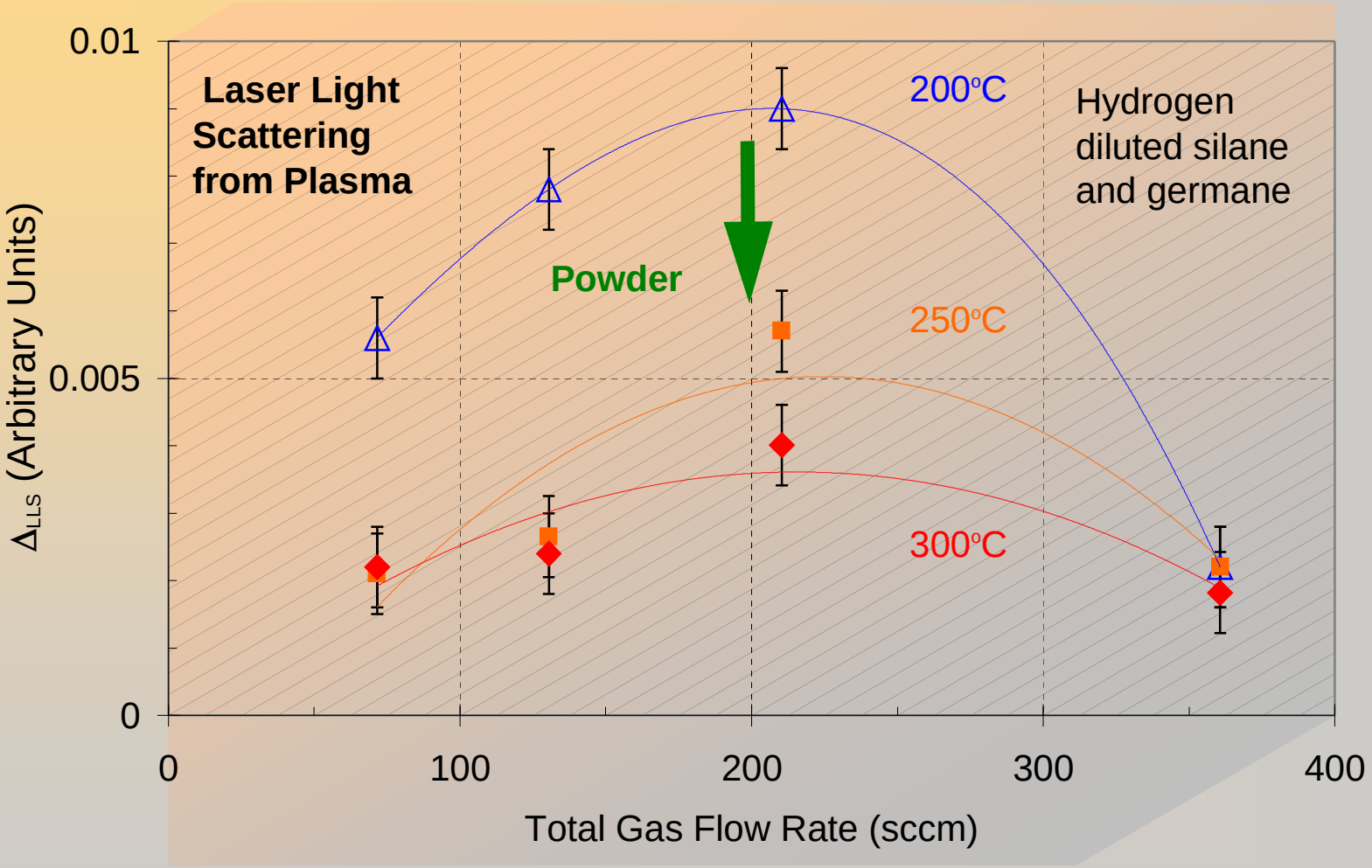
Powder decreases at higher T_s



★ Less powder implies more stable a-SiGe:H

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Higher T_s- Less Ge

Sample	State	V_{oc}	FF	J_{sc}	P_{max}
		(V)		(mA/cm^2)	(mW/cm^2)
9890 LC1	Std.	0.601	0.577	7.36	2.55
9887 LC1	Higher	0.59	0.584	7.71	2.66
9904 LC1	Highest	0.613	0.598	7.44	2.73

- Increasing the temperature reduces the hydrogen content and less germanium is required to obtain the same V_{oc}
- The initial performance improves and stability is expected to be better

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From Disilane to Silane

Sample	State	V_{oc}	FF	Jsc	P_{max}
		(V)		(mA/cm^2)	(mW/cm^2)
Disilane					
8364 LC1	initial	0.595	0.644	8.09	3.10
	1012 h	*0.565*	*0.581*	*7.80*	*2.60*
Silane					
9917 LC1	Initial	0.594	0.583	7.79	2.70
	1008 h	*0.571*	*0.514*	*7.44*	*2.18*

- Bottom cells deposited using ‘production constraints’ (high rate, etc.)
- Performance of bottom cell with silane not quite as good as disilane (84%)

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Improved Germane Grading

Sample	State	V_{oc}	FF	Jsc	P_{max}
		(V)		(mA/cm^2)	(mW/cm^2)
Standard					
9917 LC1	Initial	0.594	0.583	7.79	2.70
	1008 h	*0.571*	*0.514*	*7.44*	*2.18*
Grading 1					
10044 LC1	Initial	0.594	0.645	7.75	2.97
	1000 h	*0.564*	*0.55*	7.36	2.28
Grading 2					
10058 LC1	Initial	0.598	0.649	7.73	3.00
	1000 h	*0.566*	*0.566*	7.32	2.35

- Improved performance with Ge grading adapted to higher rate bottom cell
- Performance is 90% of that with disilane

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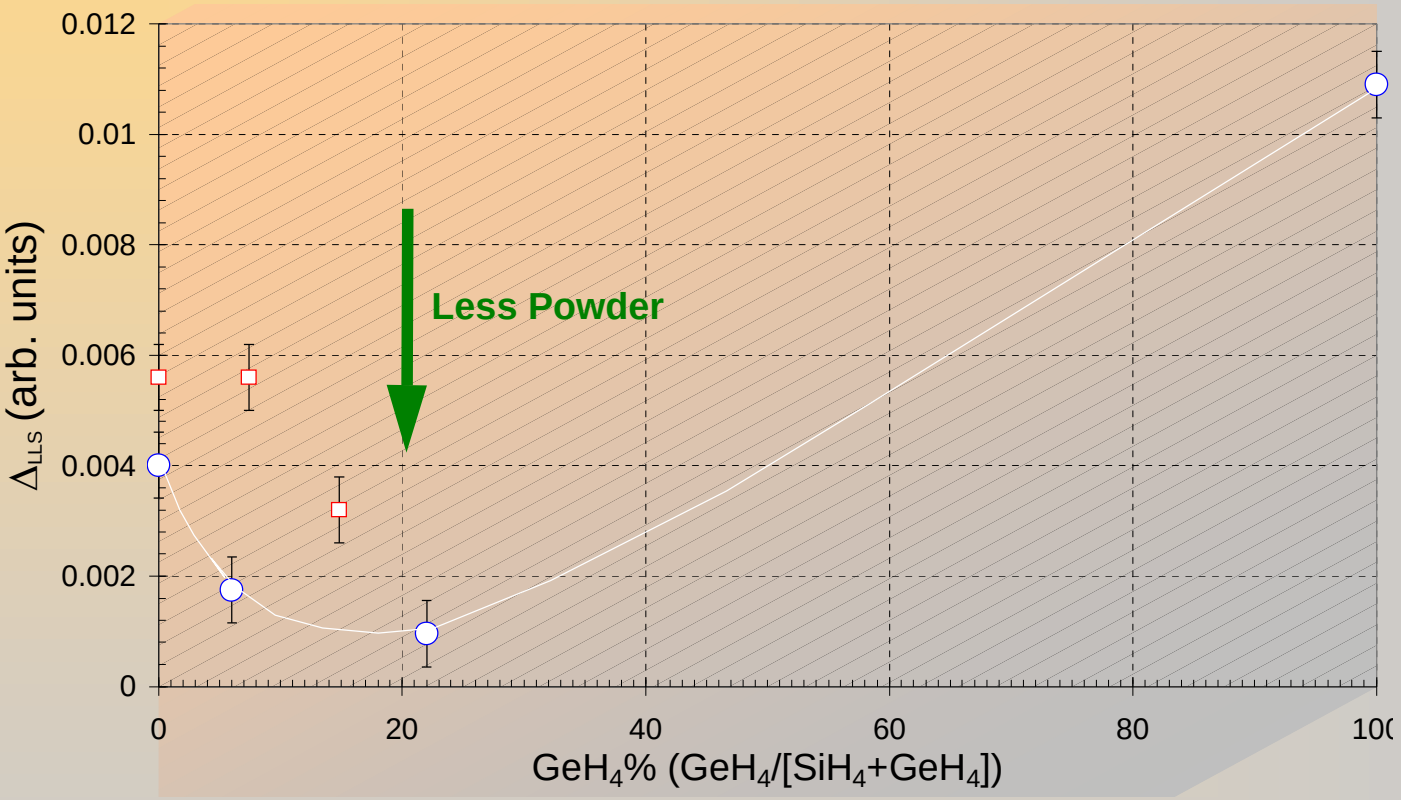
Less powder at low Ge/Si



- Sweet spot at low germane fraction

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High Rate Middle Cell

Sample	State	V_{oc}	FF	Jsc	P_{max}
		(V)		(mA/cm^2)	(mW/cm^2)
Disilane					
8316 B0	Initial	0.718	0.697	7.70	3.85
	1055h	*0.664*	*0.598*	*7.22*	*2.87*
Silane -standard					
9941 LC1	Initial	0.702	0.678	7.37	3.51
	1008h	*0.648*	*0.571*	*7.08*	*2.62*
Silane -grading 1					
10049 LC1	Initial	0.691	0.694	7.58	3.64
	1000h	*0.645*	*0.586*	*7.29*	*2.75*
Silane -grading 2					
10046 LC1	Initial	0.685	0.704	7.74	3.73
	1000h	*0.639*	*0.584*	*7.43*	*2.77*

- The middle cell also improves to 97% of that with disilane

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Conclusions

- We have improved the stable, total area performance of the high rate bottom cell from 2.18 to 2.35 mW/cm^2
- The middle cell has been improved from 2.62 to 2.77 mW/cm^2
- Higher temperature, less germanium and grading adapted to higher rate deposited material have been used.

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